FORM PTO-1390 (Modified)
(REV 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

531 Rec'd PCT/PTO 22 JAN 2002

ATTORNEY'S DOCKET NUMBER
112740-520

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)
10/031564

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/01253	**20 April 2000**	**22 July 1999**

TITLE OF INVENTION
METHOD AND DEVICE FOR PROVIDING ERROR PROTECTION FOR A DATA BIT STREAM

APPLICANT(S) FOR DO/EO/US
Wen Xu

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☒ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☐ Other items or information:

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 10/031564	INTERNATIONAL APPLICATION NO. PCT/DE00/01253	ATTORNEY'S DOCKET NUMBER 112740-520

24. The following fees are submitted:

531 Rec'd PCT/PTO 22 JAN 2002

		CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :			
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1040.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$890.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$740.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).	☐ 20 ☐ 30	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	15 - 20 =	0	x $18.00	**$0.00**	
Independent claims	2 - 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims **(check if applicable).**			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$890.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$890.00**	
Processing fee of **$130.00** for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).			☐ 20 ☐ 30 +	**$0.00**	
TOTAL NATIONAL FEE =				**$890.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	**$0.00**	
TOTAL FEES ENCLOSED =				**$890.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$890.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ______________ in the amount of ______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **02-1818** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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REGISTRATION NUMBER

January 22, 2002
DATE

10/031564
531 Rec'd PCT 22 JAN 2002

BOX PCT

IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

PRELIMINARY AMENDMENT

APPLICANTS:	Wen Xu	DOCKET NO.:	112740-520
SERIAL NO:		GROUP ART UNIT:	
FILED:		EXAMINER:	
INTERNATIONAL APPLICATION NO::		PCT/DE00/01253	
INTERNATIONAL FILING DATE		20 April 2000	
INVENTION:	METHOD AND DEVICE FOR PROVIDING ERROR PROTECTION FOR A DATA BIT STREAM		

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Please amend the above-identified International Application before entry into the National stage before the U.S. Patent and Trademark Office under 35 U.S.C. §371 as follows:

In the Specification:

Please replace the Specification of the present application, including the Abstract, with the following Substitute Specification:

SPECIFICATION

TITLE OF THE INVENTION

METHOD AND DEVICE FOR PROVIDING ERROR PROTECTION FOR A DATA BIT STREAM

BACKGROUND OF THE INVENTION

Source signals such as voice, sound, image and video almost always include statistical redundancy. As a result of source decoding it is possible to remove this redundancy, with the result that an efficient transition or storage of the source signal is made possible. On the other hand, when transmitting signals it is necessary to reinsert redundancy selectively via channel coding in order to eliminate channel interference.

Owing to the incomplete knowledge of the source signals or restrictions in the complexity of the coding method, the source coding usually can be implemented only in a less than optimum fashion; i.e., there is still a certain degree of redundancy in compressed data. This residual redundancy can be utilized in what is referred to as source-controlled or common channel decoding for correcting further bit errors; cf. DE 4224214 C2 and J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pp. 2449-2457, Sept, 1995. Here, the decoding process of the channel decoder is controlled both by the transmitted code bits and by an Apriori-A Posteriori information item relating to the probable value of a number of important source bits. In the case of VA (Viterbi-Algorithm) decoding, this method was referred to as Apri-VA. It already has been applied successfully for the transmission of voice, sound, image and video.

The bits (information bits) generated by source coding generally have highly varying degrees of sensitivity to bit errors which can arise, for example, in digital telecommunications transmission/storage so that unequal error protection (UEP) is necessary for different bits; i.e., important bits must be better protected than less important ones.

An example is the voice codec, such as the enhanced full rate (EFR) and adaptive multirate (AMR) voice codec in the GSM standard, the speech codec being based on the CELP (code excited linear prediction). The GSM-EFR codec generates 244 bits (corresponding to 12.2 kbit/s) every 20 ms (corresponding to one frame). Errors in this bit stream have greatly varying effects on the voice quality after decoding. Errors in a large number of bits, for example, bits of LPC (linear predictive coding) coefficients, lead to incomprehensibility or loud noises, while errors in other bits (for example, bits from fixed code books) are virtually imperceptible. This has given impetus to dividing up the bits, according to the voice coder, into classes (Class 1a, 1b and 2) which are usually differently protected against errors. In order to obtain a reasonable voice quality, it is typically necessary (depending on the type of codec and quality requirement), to protect the most important bits up to a bit error rate BER of approximately $10^{-4} - 10^{-5}$ (after channel decoding) and to protect the least important bits up to a bit error rate BER of $10^{-1} - 10^{-2}$. This method is referred to as the UEP method.

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The customary methods for implementing a UEP are:

- use of special codes which have a UEP mechanism (cf., for example, H. Ma, "Binary unequal error-protection block codes formed from convolutional codes by generalized tail-biting," IEEE Trans. Information Theory, Vol. 32, pp. 776-786, 1986).
- separate channel coding of the different classes of bits (for example, in GSM-EFR; the bits of classes 1a and 1b are coded by a convolutional code at the rate 1/2 and memory $m = 4$, and the bits of class 2 are transmitted in uncoded form).
- combination of channel coding and subsequent puncturing which is adapted to the importance of the bits (example: GSM-AMR standard).

The third generation of mobile telephone systems 3GPP (third generation partner project) or UMTS (universal mobile telecommunication system) is currently being standardized. For general data transmission, a uniform structure already has been agreed (*see:* Figure 4-1 and Figure 4-2 of *Transport channel multiplexing structure for uplink, in TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)).*

The channel coding is implemented with a convolutional code (rate 1/2 and 1/3, constraint length m+1=9, m being referred to as code memory) or turbo codes. The rate matching serves here to repeat the code bits generated by the channel coding in accordance with the quality of the service and/or the possible (fixed) length of the data block within a transport channel (if the code bits are too few) or to puncture them (if the code bits are too many). All functional units (CRC, multiplexing, channel coding, interleaving, rate matching, etc) may be applied to the entire data block (i.e., the complete input bit stream) but not parts thereof.

Although such a structure makes the system simple and uniform for different services, it is difficult to implement a UEP, for example, for voice services, with the customary methods of channel coding. In order to adapt the importance of the AMR-coded bits, the different classes of bits should be transmitted with different levels of protection. A simple solution is to transmit the different classes of bits via different transport channels.

Disadvantages of such a UEP solution are the complicated management of the decomposition and combination of bits and the overhead necessary for these processes.

We will consider the mode 12.2 kbit/s of the AMR codec as an example. This mode has 3 classes of bits: Class A (81 bits), Class B (103 bits) and Class C (60 bits). If the 3 classes of bits are transmitted via 3 transport channels, each class firstly has, for example, 16 CRC bits (for block error detection) added to it and then 8 tail bits (if, as foreseen, the convolutional code with rate 1/3, constraint length 9 is used). The entire code bits after channel coding are 3x(81+16+8) + 3x(103+16+8) + 3x(60+16+8) = 948 bits, of which 3x(16+8) + 3x(16+8) + 3x(16+8) = 216 bits, i.e., 216/948 ≈ 23% of all code bits, are associated with the overhead. If, however, all 244 bits are transmitted with a transport channel, the overhead is 3x(16+8) = 72 bits (these bits are necessary for UMTS data transmission), i.e., 72/804 ≈ 9% of all code bits, where 804 = (244+16+8) x 3.

The present invention is, therefore, directed toward specifying an improved method of the generic type with reduced expenditure on protection (overhead) and, thus, a relatively high net information density, together with a corresponding device.

SUMMARY OF THE INVENTION

The present invention includes the fundamental idea of selective insertion of known bits before the channel coding step. These known bits, also referred to below as dummy bits, are inserted in the vicinity of the important information bits, specifically in a non-terminating fashion (in contrast with the known code termination where a known bit group is located at the end of a data block), and in particular on both sides of the information bits. The more important an information bit is, the nearer its dummy bits should be located to it and/or the more known bits should be inserted near to it.

A code with a relatively low rate is advantageously formed by inserting the previously known bits from a code with a relatively high rate. The application to a systematic code is particularly expedient, and the inserted previously known bits (dummy bits) are not included in the transmission in the code bits.

An advantageous linking to puncturing is also expedient by puncturing the code bits after application of the proposed method.

Decoding methods such as the source-controlled channel decoding can be used in conjunction with the proposed method, the maximum (absolute) apriori knowledge (the log-likelihood ratio in the case of Apri-VA algorithm) for the known bits being set at the receiver end.

Potential advantages of the proposed method are:

- Simplicity of implementation. With the exception that a channel decoder which uses apriori knowledge (for example, the Apri-VA algorithm instead of the normal VA (Viterbialgorithm) is used, all other parts of the channel codec remain unchanged. As a result, a UEP can be implemented for a predetermined transmission structure (such as 3 GPP) without further modification.
- Flexibility. It is easy to adapt UEP to individual information bits.
- Omission of a separate overhead.

For the above example (12.2 kbit/s AMR-codec for UMTS), it is possible to transmit all 244 bits within a transport channel using the method proposed here.

While the execution, specifically in the case of unequal error protection, only requires one classification of the information bits into two classes, namely more important (more significant) and less important (less significant), in one preferred embodiment a finely graduated classification into at least three classes takes place associated with the insertion of several successive dummy bits, in each case, near to information bits with a higher significance and of one dummy bit near to information bits with medium ranking significance.

In a device which is suitable for carrying out the method according to the present invention, the coder includes parts for inserting the previously known data bits (dummy bits) at positions near to the positions of important information bits. Such a device also includes a classification device for classifying information bits according to their significance or it is at least connected to a source of corresponding classification signals; for example, to a memory device of an external classification device.

For decoding the received (convolution–coded) bit stream, it is possible, for example, to use a Viterbi-Algorithm (VA) which is modified as follows. A trellis diagram of a convolutional code is composed of branches (state transitions) and nodes,

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it being possible for a number of branches to come together at each node. A node represents a state of the memory of the convolutional code. For a rate 1/n convolutional code and at a specific point in time there are branches to the next point in time in the trellis diagram 2^{m+1} if no bit is predefined. If a dummy bit is inserted, only 2^m branches are then possible. The normal Viterbi decoder then can be modified in such as way that only these branches are reached. In other words, the paths which do not run over the 2^m branches are rejected. This method can be expanded for several dummy bits and other codes.

Here, such a system includes a sequence controller for controlling the corresponding tests for the data bit streams processed via a number of paths in the trellis diagram, by reference to the positions and the values of the dummy bits, as well as a decision unit which is connected to the comparative device and makes a decision to reject or to confirm or select a path as a function of the result of the comparison which is respectively made.

In a further preferred embodiment, such an overall system includes a source-controlled channel decoder which implements, in particular, an Apri-Viterbi-Algorithm or MAP-Algorithm. Such a channel decoder includes a database for what are referred to as "L values" (values of the log-likelihood ratio) of the inserted known bits.

The proposed method has particular practical significance for the error-protected transmission of source signals; in particular, voice signals. It is therefore particularly suitable for application in a mobile telephone system.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 shows a schematic view of a data bit stream before the channel coding or upstream of the corresponding apriori knowledge base for channel decoding.

Fig. 2 shows a simulation of the BER as a function of the bit number of a VA decoder of an AWGN channel.

Fig. 3 shows a view of the protection of a convolutional code with predetermined dummy bits.

Fig. 4 shows a view of the simulation of an RSC code of an AWGN channel.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated in Fig. 1, the bits u_3 and u_4 should be better protected than u_8 and u_9, which are, in turn, better protected than u_1, u_6, u_7, ... Two known bits ("0" or "1") can then be inserted between u_3 and u_4 and a known bit ("0" or "1") can be inserted between u_8 and u_9. This apriori knowledge should be used at the decoding end; i.e., the two bits between u_3 and u_4 are "0" and the bit between u_8 and u_9 is "1".

The following methods are possible for decoding:

- In the case of a normal VA, it is possible, for example, to use this apriori knowledge in the selection of the possible paths; i.e., paths with which the known bits are incorrectly decoded are rejected. This is similar to the termination of a convolutional code.
- When an Apri-VA or a similar algorithm, for example, the MAP (maximum a posteriori probability) decoding algorithm, is used, the apriori L values for the known dummy bits can be used as acceptable maximum values (e.g. $L = +\infty$ for bit "O" and $L = -\infty$ for bit "1"). For the information bits u_1, u_2, u_3, u_4, ... $L_I = 0$ $(i = 1,2,...)$ if no apriori knowledge is present.
- For systematic channel codes such as, for example, the recursive systematic convolutional codes which are already used in the GSM-AMR channel coding and also as component codes in turbo codes, the Apriori L value of an information bit firstly can be added to the channel soft value (i.e., soft input value of the channel decoder) of the corresponding systematic code bit (= information bit) and the resulting soft value then can be used as a soft input value of the channel decoder. In this way, a channel decoder which uses Apriori knowledge (for example, the Apri-VA algorithm)can be implemented directly with a conventional VA (without modification).

Fig. 2 shows the simulation results for a convolutional code with constraint length $m+1 = 5$ and rate 1/3 under an AWGN (additive white Gaussian noise) channel. The block length is 200 (bit 0...199). The generator polynomials used are

$$G_1 = 1 + D^3 + D^4$$

$$G_2 = 1 + D + D^2 + D^4$$

$$G_3 = 1 + D^2 + D^3 + D^4$$

the codes having a known initial state and being terminated at the end of the data block with m tailbits (4 bits = 0 in our case).

The unbroken lines (with symbol "+") show the BER of all 200 information bits using normal coding/decoding (without dummy bits), and the broken lines (with the symbol "x") show the BER if known dummy bits are at the bit positions 9, 11, 15, 49, 89, 90, 129, 130, 131, 169, 170, 171, 172 (and the Apri-VA is used here). It is possible to infer that without taking into account the dummy bits whose BER = 0, the information bits directly next to the dummy bits have a lower BER than the information bits a long way from the dummy bits. As a result, a UEP is achieved. The various parallel lines represent the various channel conditions (from top to bottom, the signal-to-noise ratio S/N = -5.0, -4.5, -4.0, -3.5, -3.0, -2.5, -2.0, -1.5, -1.0...).

It is to be noted:

- that the bits at the start and end of the datablock likewise have a lower BER. This is a consequence of the known starting states and final states (if terminated) of the convolutional code. In fact, the method proposed here is based on a similar principle to code termination. The difference is that during the termination the known bits are used *only* at the end of the datablock (all at once) because otherwise without termination the bits at the end of the datablock are significantly less well protected than the other bits. On the other hand, in our proposal, the known bits in the vicinity of the bits which are to be better protected are generally used more than once.
- by using additional dummy bits (i.e., inserting more redundancy), the information bits are always better protected. There is no degradation of the performance.
- the additional protective effect of the dummy bits is also basically restricted to the constraint length of the code, similarly to the termination of a convolutional code. Depending on how many dummy bits are used, the protective range can be 2 to 3 times the constraint length ($m+1$). If, for example, the constraint length is equal to 5, the bits which are at a distance of up to 10-15 bits from the dummy bits can be additionally protected.
- for a normal non-systematic convolutional code, not more than m bits are to be used in succession as dummy bits (m = *code memory*), because with m bits the

code is already terminated; i.e., a further reduction of the BER by more than m bits is not possible.

Fig.3 shows that the bit $\mathbf{u_4}$ is best protected by 8 dummy bits (4 on the left-hand side and 4 on the right-hand side) for a non-systematic convolutional code where $m = 4$.

The above explanations apply to convolutional codes, but the principle can be applied to all codes for which correlation between the code bits placed in a serial arrangement is present after coding (for example, turbo codes).

The proposed method is particularly attractive and efficient for systematic channel codes (for example, the recursive systematic convolutional/RSC codes or turbo codes) because the identical inserted dummy bits (for example, "0's") are mirrored into the code words (as systematic code bits) and do not need to be transmitted.

This will be explained with an example: If the bits a-b-c-**0**-**d**-**0**-e-f-g-... are channel-coded with a code with a rate 1/2 and transmitted where a-b-c-**d**-e-f-g are the data bits and **d** is to be protected better by inserting two **0**'s, the coded bits (code bits or code words) have a form aA-bB-cC-**OX-dD-OX**-eE-fF-gG- ... in the case of a systematic code. Here, **X** $\in$ {0, 1} applies to a, A, b, B,..., and in general **X** = a desired number (the first **X** is not necessarily equal to the second **X**). Because the two dummy bits **0** at the receiver end are known, we only need to transmit the bits aA-bB-cC-**X**-**dD**-**X**-eE-fF-gG-... . The dummy bits which are not transmitted can, if appropriate, be reset before decoding (with maximum reliability). This corresponds to a lower equivalent code rate. In the case of a non-systematic code, the coded bits generally have a form AA-BB-CC-XX-DD-XX-EE-FF-GG which should/must all be transmitted.

All codes with relatively low rates generally can be formed (systematically or non-systematically) from codes with relatively high rates using this method (see the following example). It is, therefore, possible for this method to be combined with puncturing via which codes with relatively high rates can be generated from codes with relatively low rates in order to achieve a desired (any) code rate and/or an optimum performance.

For example: We can form a systematic code with the rate 1/3 from a systematic code with the rate 1/2, namely by regular insertion of 0: a-**0**-b-**0**-c-**0**-d-**0**-...

If these bits are coded with a rate 1/2 code, aA-**0X**-bB-**0X**-cC-**0X**-dD-**0X**-... are obtained. The bits to be transmitted are then aA-**X**-bB-**X**-cC-**X**-dD-**X**-... . The equivalent code rate is 1/3 because a rate 1/3 code generates the same number of code bits, specifically aA**X**-bB**X**-cC**X**-dD**X**-... . Similarly, we can form codes of equivalent rates 2/5 (a-b-c**0**-c-d-**0**-e...), 3/7 (a-b-c-**0**-d-e-f-**0**-...), ... from a systematic code with a rate 1/2. In our simulation it has been shown that a rate 1/3 code which is formed in this way almost supplies the same performance as the optimum rate 1/3 code.

The following information applies to Fig. 4: *m=8,* AWGN channel, RSC code with the polynorms from *TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)*, where

- m8r2rscvach0.pro.-3 = code with a rate 1/2, channel E_S/N_0 = -3 dB
- m8r3rscvach0.pro-3 = code with a rate 1/3, channel E_S/N_0 = -3 dB
- m8r2rscvach0_a1p2.pro.-3 = code with an equivalent rate of 1/3, channel E_S/N_0 = -3 dB (proposed method)
- m8r2rscvach0_a1p3.pro.-3 = code with an equivalent rate of 2/5, channel E_S/N_0 = -3 dB (proposed method)
- m8r2rscvach0_a1p4.pro.-3 = code with an equivalent rate of 3/7, channel E_S/N_0 = -3 dB (proposed method)
- m8r2rscvach0_a1p5.pro.-3 = code with an equivalent rate of 4/9, channel E_S/N_0 = -3 dB (proposed method)

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

A method and device for providing error protection for a data bit stream in a digital telecommunications transmission system in order to reduce the bit error rate, wherein, before channel coding, a number of previously known dummy bits are inserted in a non-terminating fashion at predetermined bit positions in a primary data bit stream on both sides of information-carrying bits.

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<u>In the claims</u>:

On page 15, cancel line 1 and substitute the following left hand justified heading therefor.

CLAIMS

Please cancel Claims 1-15, without prejudice, and substitute the following claims therefor:

16. A method for providing error protection for a data bit stream in a digital telecommunications transmission system for reducing a bit error rate, the method comprising the steps of:

establishing a plurality of known dummy bits; and

inserting, before channel coding, the plurality of known dummy bits in a non-terminating fashion at predetermined bit positions in a primary data bit stream on both sides of information-carrying bits.

17. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 16, the method further comprising the step of forming a code with a relatively low rate from a code with a relatively high rate via the insertion of the known dummy bits.

18. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 16, wherein the method is applied to a systematic code, the dummy bits not being transmitted in code bits.

19. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 18, wherein the code bits are subsequently punctured.

20. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 16, the method further comprising the step of subjecting the information-carrying bits of the primary data bit stream to classification of their significance into at least two classes, wherein the dummy bits are inserted near the information-carrying bits which carry information to a significant degree.

21. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 16, wherein the method is applied in a mobile telephone system.

22. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 16, wherein the method is applied for transmission of voice signals.

23. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 19, wherein the method is applied to a convolutional code.

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24. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 19, the method further comprising the step of carrying out a path selection, at a receiver end, within a framework of a Viterbi algorithm, based on the protected data bit stream, a resemblance between the process data bit stream and the protected data bit stream being checked in each case at locations of the dummy bits and the respective path being rejected in the case of non-correspondence.

25. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 24, the method further comprising the step of decoding the protected data bit stream as source-controlled channel decoding via one of an Apri-Viterbi algorithm and a MAP algorithm.

26. A method for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 24, the method further comprising the steps of:

adding an Apriori-L value of an information bit to a soft input value of the corresponding systematic code bit for a recursive, systematic convolutional code; and

effecting decoding via a conventional Viterbi algorithm.

27. A device for providing error protection for a data bit stream in a digital telecommunications transmission system for reducing a bit error rate, the device comprising a coder for inserting previously known data bits at predetermined bit positions of a primary data bit stream to be coded.

28. A device for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 27, further comprising a classification device for classifying a significance of the information bits of the primary data bit stream, an output of the classification device being connected to a controller for controlling the insertion of the known data bits.

29. A device for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 27, wherein for decoding information bits via a Viterbi algorithm, the device further comprises:

a sequencing control unit for controlling checking of a plurality of paths for the received data bit stream;

a comparitor unit for checking the data bit streams which are processed via a plurality of paths, by reference to the positions and values of the dummy bits; and

a decision unit, connected to an output of the comparitor unit, for rejecting or approving the path assigned to the respectively tested data bit stream as a result of the comparison.

30. A device for providing error protection for a data bit stream in a digital telecommunications transmission system as claimed in Claim 27, further comprising a source-controlled channel decoder for executing one of an Apri-Viterbi algorithm and a MAP algorithm.

REMARKS

The present amendment makes editorial changes and corrects typographical errors in the specification, which includes the Abstract, in order to conform the specification to the requirements of United States Patent Practice. No new matter is added thereby. Attached hereto is a marked-up version of the changes made to the specification by the present amendment. The attached page is captioned **"Version With Markings To Show Changes Made".**

In addition, the present amendment cancels original claims 1-15 in favor of new claims 16-30. Claims 16-30 have been presented solely because the revisions by red-lining and underlining which would have been necessary in claims 1-15 in order to present those claims in accordance with preferred United States Patent Practice would have been too extensive, and thus would have been too burdensome. The present amendment is intended for clarification purposes only and not for substantial reasons related to patentability pursuant to 35 U.S.C. §§101, 102, 103 or 112. Indeed, the cancellation of claims 1-15 does not constitute an intent on the part of the Applicants to surrender any of the subject matter of claims 1-15.

Early consideration on the merits is respectfully requested.

Respectfully submitted,

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531 Rec'd PCT/PTO 22 JAN 2002

VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

In The Specification:

The Specification of the present application, including the Abstract, has been amended as follows:

~~Description~~

SPECIFICATION

TITLE OF THE INVENTION

~~Method and Device for Providing Error Protection for a Data Bit Stream~~

METHOD AND DEVICE FOR PROVIDING ERROR PROTECTION FOR A DATA BIT STREAM

~~The invention relates to a method for providing error protection as claimed in the preamble of claim 1, and to a device for carrying out this method.~~

BACKGROUND OF THE INVENTION

Source signals such as voice, sound, image and video almost always include statistical redundancy. As a result of source decoding it is possible to remove this redundancy, with the result that an efficient transition or storage of the source signal is made possible. On the other hand, when transmitting signals it is necessary to reinsert redundancy selectively ~~by means of~~ via channel coding in order to eliminate channel interference.

Owing to the incomplete knowledge of the source signals or restrictions in the complexity of the coding method, the source coding ~~can~~ usually ~~only~~ can be implemented only in a less than optimum fashion; i.e., there is still a certain degree of redundancy in compressed data. This residual redundancy can be utilized in what is referred to as source-controlled or common channel decoding for correcting further bit errors; cf. DE 4224214 C2 and J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pp. 2449-2457, Sept, 1995. Here, the decoding process of the channel decoder is controlled both by the transmitted code bits and by an Apriori-A Posteriori information item relating to the probable value of a number of important source bits. In the case of VA (Viterbi-Algorithm) decoding, this method was referred to as Apri-VA. It ~~has~~ already has been applied successfully for the transmission of voice, sound, image and video.

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The bits (information bits) generated by source coding generally have highly varying degrees of sensitivity to bit errors which can arise, for example, in digital telecommunications transmission/storage so that unequal error protection (UEP) is necessary for different bits~~,~~; i.e., important bits must be better protected than less important ones.

An example is the voice codec, ~~for example~~ such as the enhanced full rate (EFR) and adaptive multirate (AMR) voice codec in the GSM standard, ~~said~~ the speech codec being based on the CELP (code excited linear prediction). The GSM-EFR codec generates 244 bits (corresponding to 12.2 kbit/s) every 20 ms (corresponding to one frame). Errors in this bit stream have greatly varying effects on the voice quality after decoding. Errors in a large number of bits, for example, bits of LPC (linear predictive coding) coefficients, lead to incomprehensibility or loud noises, while errors in other bits (for example, bits from fixed code books) are virtually imperceptible. This has given impetus to dividing up the bits, according to the voice coder, into classes (Class 1a, 1b and 2) which are usually differently protected against errors. In order to obtain a reasonable voice quality, it is typically necessary (depending on the type of codec and quality requirement), to protect the most important bits up to a bit error rate BER of approximately $10^{-4} - 10^{-5}$ (after channel decoding) and to protect the least important bits up to a bit error rate BER of $10^{-1} - 10^{-2}$. This method is referred to as the UEP method.

The customary methods for implementing a UEP are:

- use of special codes which have a UEP mechanism (cf., for example, H. Ma, "Binary unequal error-protection block codes formed from convolutional codes by generalized tail-biting," IEEE Trans. Information Theory, Vol. 32, pp. 776-786, 1986).
- separate channel coding of the different classes of bits (for example, in GSM-EFR; the bits of classes 1a and 1b are coded by a convolutional code at the rate 1/2 and memory $m = 4$, and the bits of class 2 are transmitted in uncoded form).
- combination of channel coding and subsequent puncturing which is adapted to the importance of the bits (example: GSM-AMR standard).

The third generation of mobile telephone systems 3GPP (third generation partner project) or UMTS (universal mobile telecommunication system) is currently being standardized. For general data transmission, a uniform structure ~~has~~ already has been agreed (*see:* Figure 4-1 and Figure 4-2 of *Transport channel multiplexing structure for uplink, in TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)).*

The channel coding is implemented with a convolutional code (rate 1/2 and 1/3, constraint length m+1=9, m being referred to as code memory) or turbo codes. The rate matching serves here to repeat the code bits generated by the channel coding in accordance with the quality of the service and/or the possible (fixed) length of the data block within a transport channel (if the code bits are too few) or to puncture them (if the code bits are too many). All functional units (CRC, multiplexing, channel coding, interleaving, rate matching, etc) may be applied to the entire data block (i.e., the complete input bit stream) but not parts thereof.

Although such a structure makes the system simple and uniform for different services, it is difficult to implement a UEP, for example, for voice services, with the customary methods of channel coding. In order to adapt the importance of the AMR-coded bits, the different classes of bits should be transmitted with different levels of protection. A simple solution is to transmit the different classes of bits via different transport channels.

Disadvantages of such a UEP solution are the complicated management of the decomposition and combination of bits and the overhead necessary for ~~said~~ these processes.

We will consider the mode 12.2 kbit/s of the AMR codec as an example. This mode has 3 classes of bits: Class A (81 bits), Class B (103 bits) and Class C (60 bits). If the 3 classes of bits are transmitted via 3 transport channels, each class firstly has, for example, 16 CRC bits (for block error detection) added to it and then 8 tail bits (if, as foreseen, the convolutional code with rate 1/3, constraint length 9 is used). The entire code bits after channel coding are 3x(81+16+8) + 3x(103+16+8) + 3x(60+16+8) = 948 bits, of which 3x(16+8) + 3x(16+8) + 3x(16+8) = 216 bits, i.e., 216/948 ≈ 23% of all code bits, are associated with the overhead. If, however, all 244 bits are

transmitted with a transport channel, the overhead is 3x(16+8) = 72 bits (these bits are necessary for UMTS data transmission), i.e., 72/804 ≈ 9% of all code bits, where ~~804 = (244+16+8) x 3~~ 804 = (244+16+8) x 3.

The present invention is, therefore ~~based on the object of~~, directed toward specifying an improved method of the generic type with reduced expenditure on protection (overhead) and, thus, a relatively high net information density, together with a corresponding device.

SUMMARY OF THE INVENTION

The present invention includes the fundamental idea of selective insertion of known bits before the channel coding step. These known bits, also referred to below as dummy bits, are inserted in the vicinity of the important information bits, specifically in a non-terminating fashion (in contrast with the known code termination where a known bit group is located at the end of a data block), and in particular on both sides of the information bits. The more important an information bit is, the nearer its dummy bits should be located to it and/or the more known bits should be inserted near to it.

A code with a relatively low rate is advantageously formed by inserting the previously known bits from a code with a relatively high rate. The application to a systematic code is particularly expedient, and the inserted previously known bits (dummy bits) are not included in the transmission in the code bits.

An advantageous linking to puncturing is also expedient by puncturing the code bits after application of the proposed method.

Decoding methods such as the source-controlled channel decoding can be used in conjunction with the proposed method, the maximum (absolute) apriori knowledge (the log-likelihood ratio in the case of Apri-VA algorithm) for the known bits being set at the receiver end.

Potential advantages of the proposed method are:

- sSimplicity of implementation. With the exception that a channel decoder which uses apriori knowledge (for example, the Apri-VA algorithm instead of the normal VA (Viterbialgorithm) is used, all other parts of the channel codec remain unchanged. As a result, a UEP can be implemented for a

predetermined transmission structure (such as 3 GPP) without further modification.

- ~~f~~Flexibility. It is easy to adapt UEP to individual information bits.
- ~~o~~Omission of a separate overhead.

For the above example (12.2 kbit/s AMR-codec for UMTS), it is possible to transmit all 244 bits within a transport channel using the method proposed here.

While the execution, specifically in the case of unequal error protection, only requires one classification of the information bits into two classes, namely more important (more significant) and less important (less significant), in one preferred embodiment a finely graduated classification into at least three classes takes place associated with the insertion of several successive dummy bits, in each case, near to information bits with a higher significance and of one dummy bit near to information bits with medium ranking significance.

In a device which is suitable for carrying out the method according to the present invention, the coder ~~comprises means~~ includes parts for inserting the previously known data bits (dummy bits) at positions near to the positions of important information bits. Such a device also ~~comprises~~ includes a classification device for classifying information bits according to their significance or it is at least connected to a source of corresponding classification signals~~,~~; for example, to a memory device of an external classification device.

For decoding the received (convolution-coded) bit stream, it is possible, for example, to use a Viterbi-Algorithm (VA) which is modified as follows. A trellis diagram of a convolutional code is composed of branches (state transitions) and nodes, it being possible for a ~~plurality~~ number of branches to come together at each node. A node represents a state of the memory of the convolutional code. For a rate 1/n convolutional code and at a specific point in time there are branches to the next point in time in the trellis diagram 2^{m+1} if no bit is predefined. If a dummy bit is inserted, only 2^m branches are then possible. The normal Viterbi decoder then can be modified in such as way that only these branches are reached. In other words, the paths which do not run over the 2^m branches are rejected. This method can be expanded for several dummy bits and other codes.

Here, such a system ~~comprises~~ includes a sequence controller for controlling the corresponding tests for the data bit streams processed via a ~~plurality~~ number of paths in the trellis diagram, by reference to the positions and the values of the dummy bits, as well as a decision unit which is connected to the comparative device and makes a decision to reject or to confirm or select a path as a function of the result of the comparison which is respectively made.

In a further preferred embodiment, such an overall system ~~comprises~~ includes a source-controlled channel decoder which implements, in particular, an Apri-Viterbi-Algorithm or MAP-Algorithm. Such a channel decoder ~~comprises~~ includes a database for what are referred to as "L values" (values of the log-likelihood ratio) of the inserted known bits.

The proposed method has particular practical significance for the error-protected transmission of source signals~~,~~; in particular, voice signals. It is therefore particularly suitable for application in a mobile telephone system.

~~Advantages and expediencies of the invention emerge, for the rest, from the subclaims and the following explanation of specific embodiments and aspects with reference to the figures, of which:~~

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 shows a schematic view of a data bit stream before the channel coding or upstream of the corresponding apriori knowledge base for channel decoding~~,~~.

Fig. 2 shows a simulation of the BER as a function of the bit number of a VA decoder of an AWGN channel~~,~~.

Fig. 3 shows a view of the protection of a convolutional code with predetermined dummy bits ~~and,~~.

Fig. 4 shows a view of the simulation of an RSC code of an AWGN channel.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated in Fig. 1, the bits u_3 and u_4 should be better protected than u_8 and u_9, which are, in turn, better protected than u_1, u_6, u_7, ... Two known bits ("0" or "1") can then be inserted between u_3 and u_4 and a known bit ("0" or "1") can be inserted

between u_8 and u_9. This apriori knowledge should be used at the decoding end;; i.e., the two bits between u_3 and u_4 are "0" and the bit between u_8 and u_9 is "1".

The following methods are possible for decoding:

- In the case of a normal VA, it is possible, for example, to use this apriori knowledge in the selection of the possible paths;; i.e., paths with which the known bits are incorrectly decoded are rejected. This is similar to the termination of a convolutional code.
- When an Apri-VA or a similar algorithm, for example, the MAP (maximum a posteriori probability) decoding algorithm, is used, the apriori L values for the known dummy bits can be used as acceptable maximum values (e.g. $L = +\infty$ for bit "O" and L = $-\infty$ for bit "1"). For the information bits $u_1, u_2, u_3, u_4, \ldots$ $L_I = 0$ $(i = 1,2,\ldots)$ if no apriori knowledge is present.
- For systematic channel codes such as, for example, the recursive systematic convolutional codes which are already used in the GSM-AMR channel coding and also as component codes in turbo codes, the Apriori L value of an information bit ~~can~~ firstly can be added to the channel soft value (i.e., soft input value of the channel decoder) of the corresponding systematic code bit (= information bit) and the resulting soft value ~~can~~ then can be used as a soft input value of the channel decoder. In this way, a channel decoder which uses Apriori knowledge (for example, the Apri-VA algorithm)can be implemented directly with a conventional VA (without modification).

Fig. 2 shows the simulation results for a convolutional code with constraint length $m+1 = 5$ and rate 1/3 under an AWGN (additive white Gaussian noise) channel. The block length is 200 (bit 0...199). The generator polynomials used are

$$G_1 = 1 + D^3 + D^4$$

$$G_2 = 1 + D + D^2 + D^4$$

$$G_3 = 1 + D^2 + D^3 + D^4$$

the codes having a known initial state and being terminated at the end of the data block with m tailbits (4 bits = 0 in our case).

The unbroken lines (with symbol "+") show the BER of all 200 information bits using normal coding/decoding (without dummy bits), and the broken lines (with the symbol "x") show the BER if known dummy bits are at the bit positions 9, 11, 15,

49, 89, 90, 129, 130, 131, 169, 170, 171, 172 (and the Apri-VA is used here). It is possible to infer that without taking into account the dummy bits whose BER = 0, the information bits directly next to the dummy bits have a lower BER than the information bits a long way from the dummy bits. As a result, a UEP is achieved. The various parallel lines represent the various channel conditions (from top to bottom, the signal-to-noise ratio S/N = -5.0, -4.5, -4.0, -3.5, -3.0, -2.5, -2.0, -1.5, -1.0...).

It is to be noted:

- that the bits at the start and end of the datablock likewise have a lower BER. This is a consequence of the known starting states and final states (if terminated) of the convolutional code. In fact, the method proposed here is based on a similar principle to code termination. The difference is that during the termination the known bits are used *only* at the end of the datablock (all at once) because otherwise without termination the bits at the end of the datablock are significantly less well protected than the other bits. On the other hand, in our proposal, the known bits in the vicinity of the bits which are to be better protected are generally used more than once.
- by using additional dummy bits (i.e., inserting more redundancy), the information bits are always better protected. There is no degradation of the performance.
- the additional protective effect of the dummy bits is also basically restricted to the constraint length of the code, similarly to the termination of a convolutional code. Depending on how many dummy bits are used, the protective range can be 2 to 3 times the constraint length $(m+1)$. If, for example, the constraint length is equal to 5, the bits which are at a distance of up to 10-15 bits from the dummy bits can be additionally protected.
- for a normal non-systematic convolutional code, not more than m bits are to be used in succession as dummy bits (m = *code memory*), because with m bits the code is already terminated;; i.e., a further reduction of the BER by more than m bits is not possible.

Fig.3 shows that the bit $\mathbf{u}_4$ is best protected by 8 dummy bits (4 on the left-hand side and 4 on the right-hand side) for a non-systematic convolutional code where $m = 4$.

The above explanations apply to convolutional codes, but the principle can be applied to all codes for which correlation between the code bits placed in a serial arrangement is present after coding (for example, turbo codes).

The proposed method is particularly attractive and efficient for systematic channel codes (for example, the recursive systematic convolutional/RSC codes or turbo codes) because the identical inserted dummy bits (for example, "0's") are mirrored into the code words (as systematic code bits) and do not need to be transmitted.

This will be explained with an example: If the bits a-b-c-**0-d-0**-e-f-g-... are channel-coded with a code with a rate 1/2 and transmitted where a-b-c-**d**-e-f-g are the data bits and **d** is to be protected better by inserting two **0**'s, the coded bits (code bits or code words) have a form aA-bB-cC-**0X-dD-0X**-eE-fF-gG- ... in the case of a systematic code. Here, **X** $\in$ {0, 1} applies to a, A, b, B,..., and in general **X** = a desired number (the first **X** is not necessarily equal to the second **X**). Because the two dummy bits **0** at the receiver end are known, we only need to transmit the bits aA-bB-cC-**X**-dD-**X**-eE-fF-gG-... . The dummy bits which are not transmitted can, if appropriate, be reset before decoding (with maximum reliability). This corresponds to a lower equivalent code rate. In the case of a non-systematic code, the coded bits generally have a form AA-BB-CC-XX-DD-XX-EE-FF-GG which should/must all be transmitted.

All codes with relatively low rates ~~can~~ generally can be formed (systematically or non-systematically) from codes with relatively high rates using this method (see the following example). It is, therefore, possible for this method to be combined with puncturing ~~by means of~~ via which codes with relatively high rates can be generated from codes with relatively low rates in order to achieve a desired (any) code rate and/or an optimum performance.

For example: We can form a systematic code with the rate 1/3 from a systematic code with the rate 1/2, namely by regular insertion of 0: a-**0**-b-**0**-c-**0**-d-**0**-... If these bits are coded with a rate 1/2 code, aA-**0X**bB-**0X**-cC-**0X**-dD-**0X**-... are obtained. The bits to be transmitted are then aA-**X**-bB-**X**-cC-**X**-dD-**X**-... . The equivalent code rate is 1/3 because a rate 1/3 code generates the same number of code bits, specifically aA**X**-bB**X**-cC**X**-dD**X**-... . Similarly, we can form codes of equivalent

rates 2/5 (a-b-c0-c-d-0-e...), 3/7 (a-b-c-0-d-e-f-0-...), ... from a systematic code with a rate 1/2. In our simulation it has been shown that a rate 1/3 code which is formed in this way almost supplies the same performance as the optimum rate 1/3 code.

The following information applies to Fig. 4: $m=8$, AWGN channel, RSC code with the polynorms from *TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)*, where

- m8r2rscvach0.pro.-3 = code with a rate 1/2, channel $E_S/N_0 = -3$ dB
- m8r3rscvach0.pro-3 = code with a rate 1/3, channel $E_S/N_0 = -3$ dB
- m8r2rscvach0_a1p2.pro.-3 = code with an equivalent rate of 1/3, channel $E_S/N_0 = -3$ dB (proposed method)
- m8r2rscvach0_a1p3.pro.-3 = code with an equivalent rate of 2/5, channel $E_S/N_0 = -3$ dB (proposed method)
- m8r2rscvach0_a1p4.pro.-3 = code with an equivalent rate of 3/7, channel $E_S/N_0 = -3$ dB (proposed method)
- m8r2rscvach0_a1p5.pro.-3 = code with an equivalent rate of 4/9, channel $E_S/N_0 = -3$ dB (proposed method)

~~The embodiments of the invention are not restricted to the examples described above, but are also possible in a multiplicity of refinements which are within the scope of the activities of a person skilled in the art.~~

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

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Description

Method for providing error protection for a data bit stream

The invention relates to a method for providing error protection as claimed in the preamble of claim 1, and to a device for carrying out this method.

Source signals such as voice, sound, image and video almost always include statistical redundancy. As a result of source decoding it is possible to remove this redundancy, with the result that an efficient transition or storage of the source signal is made possible. On the other hand, when transmitting signals it is necessary to reinsert redundancy selectively by means of channel coding in order to eliminate channel interference.

Owing to the incomplete knowledge of the source signals or restrictions in the complexity of the coding method, the source coding can usually only be implemented in a less than optimum fashion i.e. there is still a certain degree of redundancy in compressed data. This residual redundancy can be utilized in what is referred to as source-controlled or common channel decoding for correcting further bit errors; cf. DE 4224214 C2 and J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pp. 2449-2457, Sept, 1995. Here, the decoding process of the channel decoder is controlled both by the transmitted code bits and by an Apriori-A Posteriori information item relating to the probable value of a number of important source bits. In the case of VA (Viterbi-Algorithm) decoding, this method was referred to as Apri-VA. It has already been applied successfully for the transmission of voice, sound, image and video.

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The bits (information bits) generated by source coding generally have highly varying degrees of sensitivity to bit errors which can arise, for example, in digital telecommunications transmission/storage so that unequal error protection (UEP) is necessary for different bits, i.e. important bits must be better protected than less important ones.

An example is the voice codec, for example the enhanced full rate (EFR) and adaptive multirate (AMR) voice codec in the GSM standard, said speech codec being based on the CELP (code excited linear prediction). The GSM-EFR codec generates 244 bits (corresponding to 12.2 kbit/s) every 20 ms (corresponding to one frame). Errors in this bit stream have greatly varying effects on the voice quality after decoding. Errors in a large number of bits, for example bits of LPC (linear predictive coding) coefficients lead to incomprehensibility or loud noises, while errors in other bits (for example bits from fixed code books) are virtually imperceptible. This has given impetus to dividing up the bits, according to the voice coder, into classes (Class 1a, 1b and 2) which are usually differently protected against errors. In order to obtain a reasonable voice quality, it is typically necessary (depending on the type of codec and quality requirement), to protect the most important bits up to a bit error rate BER of approximately 10^{-4} – 10^{-5} (after channel decoding) and to protect the least important bits up to a bit error rate BER of 10^{-1} – 10^{-2}. This method is referred to as the UEP method.

The customary methods for implementing a UEP are:

- use of special codes which have a UEP mechanism (cf., for example, H. Ma, "Binary unequal error-protection block codes formed from convolutional codes by generalized tail-biting," IEEE Trans. Information Theory, Vol. 32, pp. 776-786, 1986).
- separate channel coding of the different classes of bits (for example in GSM-EFR; the bits of classes 1a and 1b are coded by a convolutional code at the rate 1/2 and memory $m = 4$, and the bits of class 2 are transmitted in uncoded form).
- combination of channel coding and subsequent puncturing which is adapted to the importance of the bits (example: GSM-AMR standard).

The third generation of mobile telephone systems 3GPP (third generation partner project) or UMTS (universal mobile telecommunication system) is currently being standardized. For general data transmission, a uniform structure has already been agreed (*see:* Figure 4-1 and Figure 4-2 of *Transport channel multiplexing structure for uplink, in TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)*).

The channel coding is implemented with a convolutional code (rate 1/2 and 1/3, constraint length m+1=9, m being referred to as code memory) or turbo codes. The rate matching serves here to repeat the code bits generated by the channel coding in accordance with the quality of the service and/or the possible (fixed) length of the data block within a transport channel (if the code bits are too few) or to puncture them (if the code bits are too many). All functional units (CRC, multiplexing, channel coding,

interleaving, rate matching, etc) may be applied to the entire data block (i.e. the complete input bit stream) but not parts thereof.

Although such a structure makes the system simple and uniform for different services, it is difficult to implement a UEP, for example for voice services, with the customary methods of channel coding. In order to adapt the importance of the AMR-coded bits, the different classes of bits should be transmitted with different levels of protection. A simple solution is to transmit the different classes of bits via different transport channels.

Disadvantages of such a UEP solution are the complicated management of the decomposition and combination of bits and the overhead necessary for said processes.

We will consider the mode 12.2 kbit/s of the AMR codec as an example. This mode has 3 classes of bits: Class A (81 bits), Class B (103 bits) and Class C (60 bits). If the 3 classes of bits are transmitted via 3 transport channels, each class firstly has, for example, 16 CRC bits (for block error detection) added to it and then 8 tail bits (if, as foreseen, the convolutional code with rate 1/3, constraint length 9 is used). The entire code bits after channel coding are 3x(81+16+8) + 3x(103+16+8) + 3x(60+16+8) = 948 bits, of which 3x(16+8) + 3x(16+8) + 3x(16+8) = 216 bits, i.e. 216/948 ≈ 23% of all code bits are associated with the overhead. If, however, all 244 bits are transmitted with a transport channel, the overhead is 3x(16+8) = 72 bits (these bits are necessary for UMTS data transmission), i.e. 72/804 ≈ 9% of all code bits, where 804 = (244+16+8) x 3.

The invention is therefore based on the object of specifying an improved method of the generic type with reduced expenditure on protection (overhead) and thus a relatively high net information density, together with a corresponding device.

The invention includes the fundamental idea of selective insertion of known bits before the channel coding step. These known bits - also referred to below as dummy bits - are inserted in the vicinity of the important information bits, specifically in a non-terminating fashion (in contrast with the known code termination where a known bit group is located at the end of a data block), and in particular on both sides of the information bits. The more important an information bit is, the nearer its dummy bits should be located to it and/or the more known bits should be inserted near to it.

A code with a relatively low rate is advantageously formed by inserting the previously known bits from a code with a relatively high rate. The application to a systematic code is particularly expedient, and the inserted previously known bits (dummy bits) are not included in the transmission in the code bits.

An advantageous linking to puncturing is also expedient by puncturing the code bits after application of the proposed method.

Decoding methods such as the source-controlled channel decoding can be used in conjunction with the proposed method, the maximum

(absolute) apriori knowledge (the log-likelihood ratio in the case of Apri-VA algorithm) for the known bits being set at the receiver end.

Potential advantages of the proposed method are:

- simplicity of implementation. With the exception that a channel decoder which uses apriori knowledge (for example the Apri-VA algorithm instead of the normal VA (Viterbialgorithm) is used, all other parts of the channel codec remain unchanged. As a result, a UEP can be implemented for a predetermined transmission structure (such as 3 GPP) without further modification.
- flexibility. It is easy to adapt UEP to individual information bits.
- omission of a separate overhead.

For the above example (12.2 kbit/s AMR-codec for UMTS), it is possible to transmit all 244 bits within a transport channel using the method proposed here.

While the execution, specifically in the case of unequal error protection, only requires one classification of the information bits into two classes - namely more important (more significant) and less important (less significant), in one preferred embodiment a finely graduated classification into at least three classes takes place associated with the insertion of several successive dummy bits in each case near to information bits with a higher significance and of one dummy bit near to information bits with medium ranking significance.

In a device which is suitable for carrying out the method according to the invention, the coder comprises means for inserting the previously known data bits (dummy bits) at positions

near to the positions of important information bits. Such a device also comprises a classification device for classifying information bits according to their significance or it is at least connected to a source of corresponding classification signals, for example to a memory device of an external classification device.

For decoding the received (convolution-coded) bit stream, it is possible, for example, to use a Viterbi-Algorithm (VA) which is modified as follows. A trellis diagram of a convolutional code is composed of branches (state transitions) and nodes, it being possible for a plurality of branches to come together at each node. A node represents a state of the memory of the convolutional code. For a rate 1/n convolutional code and at a specific point in time there are branches to the next point in time in the trellis diagram 2^{m+1} if no bit is predefined. If a dummy bit is inserted, only 2^m branches are then possible. The normal Viterbi decoder then can be modified in such as way that only these branches are reached. In other words, the paths which do not run over the 2^m branches are rejected. This method can be expanded for several dummy bits and other codes.

Here, such a system comprises a sequence controller for controlling the corresponding tests for the data bit streams processed via a plurality of paths in the trellis diagram, by reference to the positions and the values of the dummy bits, as well as a decision unit which is connected to the comparative device and makes a decision to reject or to confirm or select a path as a function of the result of the comparison which is respectively made.

In a further preferred embodiment, such an overall system comprises a source-controlled channel decoder which implements, in particular, an Apri-Viterbi-Algorithm or MAP-Algorithm. Such a channel decoder comprises a database for what are referred to as "L values" (values of the log-likelihood ratio) of the inserted known bits.

The proposed method has particular practical significance for the error-protected transmission of source signals, in particular voice signals. It is therefore particularly suitable for application in a mobile telephone system.

Advantages and expediencies of the invention emerge, for the rest, from the subclaims and the following explanation of specific embodiments and aspects with reference to the figures, of which:

Fig. 1 shows a schematic view of a data bit stream before the channel coding or upstream of the corresponding apriori knowledge base for channel decoding,

Fig. 2 shows a simulation of the BER as a function of the bit number of a VA decoder of an AWGN channel,

Fig. 3 shows a view of the protection of a convolutional code with predetermined dummy bits and,

Fig. 4 shows a view of the simulation of an RSC code of an AWGN channel.

As illustrated in Fig. 1, the bits $\boldsymbol{u}_3$ and $\boldsymbol{u}_4$ should be better protected than $\boldsymbol{u}_8$ and $\boldsymbol{u}_9$, which are in turn better protected than u_1, u_6, u_7, ... Two known bits

("0" or "1") can then be inserted between u_3 and u_4 and a known bit ("0" or "1") can be inserted between u_8 and u_9. This apriori knowledge should be used at the decoding end, i.e. the two bits between u_3 and u_4 are "0" and the bit between u_8 and u_9 is "1".

The following methods are possible for decoding:

- In the case of a normal VA, it is possible, for example, to use this apriori knowledge in the selection of the possible paths, i.e. paths with which the known bits are incorrectly decoded are rejected. This is similar to the termination of a convolutional code.

- When an Apri-VA or a similar algorithm, for example the MAP (maximum a posteriori probability) decoding algorithm, is used, the apriori L values for the known dummy bits can be used as acceptable maximum values (e.g. $L = +\infty$ for bit "0" and $L = -\infty$ for bit "1"). For the information bits $u_1, u_2, u_3, u_4, \ldots$ $L_I = 0$ $(i = 1,2,\ldots)$ if no apriori knowledge is present.

- For systematic channel codes such as, for example, the recursive systematic convolutional codes which are already used in the GSM-AMR channel coding and also as component codes in turbo codes, the Apriori L value of an information bit can firstly be added to the channel soft value (i.e. soft input value of the channel decoder) of the corresponding systematic code bit (= information bit) and the resulting soft value can then be used as a soft input value of the channel decoder. In this way, a channel decoder which uses Apriori knowledge (for example the Apri-

VA algorithm) can be implemented directly with a conventional VA (without modification).

Fig. 2 shows the simulation results for a convolutional code with constraint length $m+1 = 5$ and rate 1/3 under an AWGN (additive white Gaussian noise) channel. The block length is 200 (bit 0...199). The generator polynomials used are

$$G_1 = 1 + D^3 + D^4$$
$$G_2 = 1 + D + D^2 + D^4$$
$$G_3 = 1 + D^2 + D^3 + D^4$$

the codes having a known initial state and being terminated at the end of the data block with m tailbits (4 bits = 0 in our case).

The unbroken lines (with symbol "+") show the BER of all 200 information bits using normal coding/decoding (without dummy bits), and the broken lines (with the symbol "x") show the BER if known dummy bits are at the bit positions 9, 11, 15, 49, 89, 90, 129, 130, 131, 169, 170, 171, 172 (and the Apri-VA is used here). It is possible to infer that without taking into account the dummy bits whose BER = 0, the information bits directly next to the dummy bits have a lower BER than the information bits a long way from the dummy bits. As a result, a UEP is achieved. The various parallel lines represent the various channel conditions (from top to bottom, the signal-to-noise ratio S/N = -5.0, -4.5, -4.0, -3.5, -3.0, -2.5, -2.0, -1.5, -1.0...).

It is to be noted

- that the bits at the start and end of the datablock likewise have a lower BER. This is a consequence of the known starting states and final states (if terminated) of the convolutional code. In fact, the method proposed here is based on a similar principle to code termination. The difference is that during the termination the known bits are used *only* at the end of the datablock (all at once) because otherwise without termination the bits at the end of the datablock are significantly less well protected than the other bits. On the other hand, in our proposal, the known bits in the vicinity of the bits which are to be better protected are generally used more than once.

- by using additional dummy bits (i.e. inserting more redundancy), the information bits are always better protected. There is no degradation of the performance.

- the additional protective effect of the dummy bits is also basically restricted to the constraint length of the code, similarly to the termination of a convolutional code. Depending on how many dummy bits are used, the protective range can be 2 to 3 times the constraint length ($m+1$). If, for example, the constraint length is equal to 5, the bits which are at a distance of up to 10-15 bits from the dummy bits can be additionally protected.

- for a normal non-systematic convolutional code, not more than m bits are to be used in succession as dummy bits (m = *code memory*), because with m bits the

code is already terminated, i.e. a further reduction of the BER by more than *m* bits is not possible.

Fig.3 shows that the bit $\mathbf{u}_4$ is best protected by 8 dummy bits (4 on the left-hand side and 4 on the right-hand side) for a non-systematic convolutional code where $m = 4$.

The above explanations apply to convolutional codes, but the principle can be applied to all codes for which correlation between the code bits placed in a serial arrangement is present after coding (for example turbo codes).

The proposed method is particularly attractive and efficient for systematic channel codes (for example the recursive systematic convolutional/RSC codes or turbo codes) because the identical inserted dummy bits (for example "0's") are mirrored into the code words (as systematic code bits) and do not need to be transmitted.

This will be explained with an example: If the bits a-b-c-**0**-**d**-**0**-e-f-g-... are channel-coded with a code with a rate 1/2 and transmitted where a-b-c-**d**-e-f-g are the data bits and **d** is to be protected better by inserting two **0**'s, the coded bits (code bits or code words) have a form aA-bB-cC-**0X**-**dD**-**0X**-eE-fF-gG- ... in the case of a systematic code. Here, $\mathbf{X} \in \{0, 1\}$ applies to a, A, b, B,..., and in general **X** = a desired number (the first **X** is not necessarily equal to the second **X**). Because the two dummy bits **0** at the receiver end are known, we only need to transmit the bits aA-bB-cC-**X**-**d**D-**X**-eE-fF-gG-… . The dummy bits which are not transmitted can, if appropriate, be reset before decoding (with maximum reliability). This corresponds to a lower equivalent code rate. In the case of a non-systematic code, the coded bits generally have a form AA-BB-CC-XX-DD-XX-EE-FF-GG which should/must all be transmitted.

All codes with relatively low rates can generally be formed (systematically or non-systematically) from codes with relatively high rates using this method (see the following example). It is therefore possible for this method to be combined with puncturing by means of which codes with relatively high rates can be generated from codes with relatively low rates in order to achieve a desired (any) code rate and/or an optimum performance.

For example: We can form a systematic code with the rate 1/3 from a systematic code with the rate 1/2, namely by regular insertion of 0: a-**0**-b-**0**-c-**0**-d-**0**-... If these bits are coded with a rate 1/2 code, aA-**0X**-bB-**0X**-cC-**0X**-dD-**0X**-... are obtained. The bits to be transmitted are then aA-**X**-bB-**X**-cC-**X**-dD-**X**-... . The equivalent code rate is 1/3 because a rate 1/3 code generates the same number of code bits, specifically aA**X**-bB**X**-cC**X**-dD**X**-... . Similarly, we can form codes of equivalent rates 2/5 (a-b-c**0**-c-d-**0**-e...), 3/7 (a-b-c-**0**-d-e-f-**0**-...), ... from a systematic code with a rate 1/2. In our simulation it has been shown that a rate 1/3 code which is formed in this way almost supplies the same performance as the optimum rate 1/3 code.

The following information applies to Fig. 4: *m=8*, AWGN channel, RSC code with the polynorms from *TS 25.212 V2.0.0 (1999-06), 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG), Radio Access Network (RAN); Working Group 1 (WG1)*, where

- m8r2rscvach0.pro.-3 = code with a rate 1/2, channel E_S/N_0 = -3 dB
- m8r3rscvach0.pro-3 = code with a rate 1/3, channel E_S/N_0 = -3 dB
- m8r2rscvach0_a1p2.pro.-3 = code with an equivalent rate of 1/3, channel E_S/N_0 = -3 dB (proposed method)

- m8r2rscvach0_a1p3.pro.-3 = code with an equivalent rate of 2/5, channel E_S/N_0 = -3 dB (proposed method)
- m8r2rscvach0_a1p4.pro.-3 = code with an equivalent rate of 3/7, channel E_S/N_0 = -3 dB (proposed method)
- m8r2rscvach0_a1p5.pro.-3 = code with an equivalent rate of 4/9, channel E_S/N_0 = -3 dB (proposed method)

The embodiments of the invention are not restricted to the examples described above, but are also possible in a multiplicity of refinements which are within the scope of the activities of a person skilled in the art.

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Patent Claims

1. Method for providing error protection for a data bit stream in a digital telecommunications transmissions system in order to reduce the bit error rate, characterized in that, before channel coding, a multiplicity of previously known dummy bits are inserted in a non-terminating fashion at predetermined bit positions in primary data bit stream near to information-carrying bits, in particular on both sides thereof.

2. The method as claimed in claim 1, characterized in that a code with a relatively low rate is formed from a code with a relatively high rate by means of the insertion of previously known dummy bits.

3. The method as claimed in claim 1 or 2, characterized by application to a systematic code, the dummy bits not being transmitted in the code bits.

4. The method as claimed in one of the preceding claims, characterized in that the code bits are subsequently punctured.

5. The method as claimed in one of the preceding claims, characterized in that the information bits of the primary data bit stream are subjected to classification of their significance into at least two classes and dummy bits are inserted near to bits which carry information to a significant degree.

6. The method as claimed in one of the preceding claims, characterized by application in a mobile telephone system.

7. The method as claimed in one of the preceding claims, characterized by application for the transmission of source signals, in particular of voice signals.

8. The method as claimed in one of claims 4 to 7, characterized by application to a convolutional code.

9. The method as claimed in one of the preceding claims, characterized in that at the receiver end a path selection is carried out, in particular within the framework of a Viterbi algorithm, on the basis of the protected data bit stream, the resemblance between the processed data bit stream and the protected data bit stream being checked in each case at the locations of the dummy bits and the respective path being rejected in the case of non-correspondence.

10. The method as claimed in one of the preceding claims, characterized in that the protected data bit stream is decoded as source-controlled channel decoding, in particular by means of an Apri-Viterbi algorithm or MAP algorithm.

11. The method as claimed in claim 9, characterized in that an Apriori-L value of an information bit is added to a soft input value of the corresponding

systematic code bit for a systematic channel code, in particular a recursive systematic convolutional code, and decoding is subsequently carried out by means of a conventional Viterbi-algorithm.

12. A device for carrying out the method as claimed in one of the preceding claims, characterized by a coder with means for inserting previously known data bits at predetermined bit positions of the primary data bit stream to be coded.

13. The device as claimed in claim 11, characterized by a classification device for classifying the significance of the information bits of the primary data bit stream, the output of said classification device being connected to the means for controlling the insertion of previously known data bits.

14. The device as claimed in claim 11 or 12, characterized in that a sequencing control unit for controlling the checking of a plurality of paths for the received data bit stream, a comparator unit for checking the data bit streams which are processed by means of a plurality of paths, by reference to the positions and values of the dummy bits, and a decision unit, connected to the output of the comparator unit, for rejecting or approving the path assigned to the respectively tested data bit stream, as a result of the comparison, are provided for decoding information bits, in particular by means of a Viterbi-Algorithm.

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15. The device as claimed in one of claims 11 to 13, characterized by a source-controlled channel decoder, in particular for executing an Apri-Viterbi-Algorithm or MAP-Algorithm.

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FIG 1A

	...	u_1	u_2	u_3	0	0	u_4	u_5	u_6	u_7	u_8	1	u_9	u_{10}	...

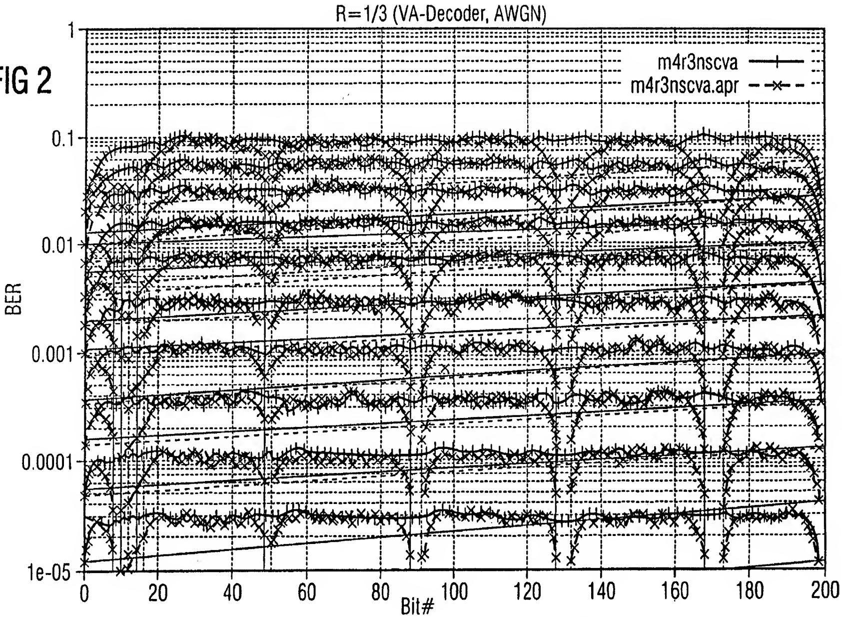
FIG 1B

	...	L_1	L_2	L_3	$+\infty$	$+\infty$	L_4	L_5	L_6	L_7	L_8	$-\infty$	L_9	L_{10}	...

FIG 3

	...	u_1	u_2	u_3	0	0	0	0	u_4	0	0	0	0	u_5	...

FIG 2


R=1/3 (VA-Decoder, AWGN)
m4r3nscva
m4r3nscva.apr
BER
1
0.1
0.01
0.001
0.0001
1e-05
Bit#
0
20
40
60
80
100
120
140
160
180
200

10031564.040202

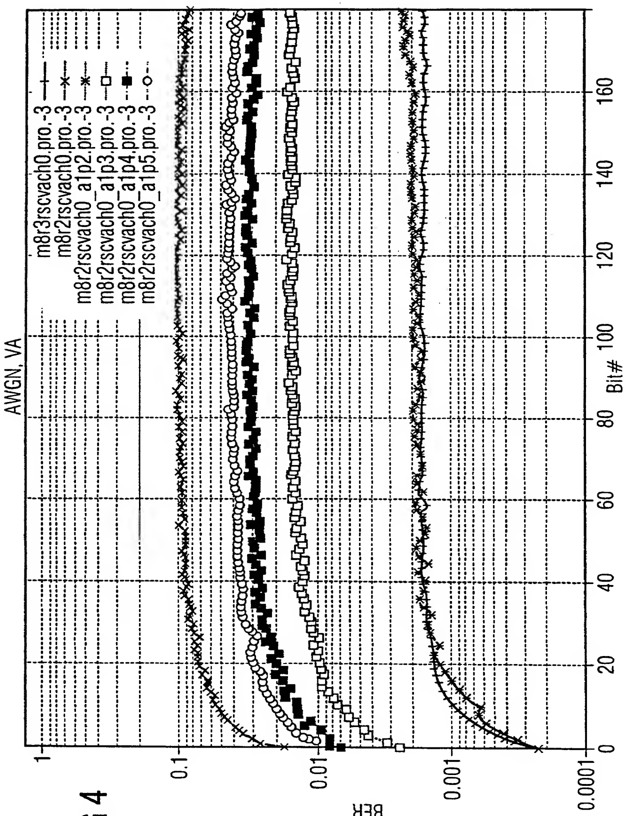


FIG 4

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren zum Fehlerschutz eines Datenbitstromes

Method of providing error protection for a data bit flow

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 20.04.2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/01253
eingereicht wurde und am _______
abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

(check one)
☐ is attached hereto.
☒ was filed on 20.04.2000 as
PCT international application
PCT Application No. PCT/DE00/01253
and was amended on _______
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

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German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

19934505.8 (Number) (Nummer)	DE (Country) (Land)	22.07.1999 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	☒ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

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PCT/DE00/01253 (Application Serial No.) (Anmeldeseriennummer)	20.04.2000 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	anhängig (Status) (patentiert, anhängig, aufgegeben)	pending (Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

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German Language Declaration

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82008 UNTERHACHING	82008 UNTERHACHING
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
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(Supply similar information and signature for third and subsequent joint inventors).